Original Article

Ultrasound-guided axillary brachial plexus block versus local infiltration anesthesia for arteriovenous fistula creation at the forearm for hemodialysis in patients with chronic renal failure

ABSTRACT

Background: The primary failure rate for arteriovenous fistula (AVF) creation under local anesthesia for hemodialysis is about 30%. Axillary brachial plexus block (BPB) may improve blood flow through blood vessels used in fistula creation; it may improve the AVF blood flow and thus may reduce the primary failure rate after 3 months.

Methods: Hundred and forty patients with chronic renal failure scheduled for AVF creation for hemodialysis were divided into two equal groups; Group 1 (AxBP-G) received ultrasound (US) guided axillary BPB, and Group 2 (LI-G) received local infiltration. We recorded the measurements of the brachial and radial arteries before and after anesthesia and the AVF blood flow in both groups at three different time points. Furthermore, the primary failure rate was recorded in each group and compared.

Results: After anesthesia, the mean radial artery blood flow in the AxBP-group was 3.52 ml/min more than the LI-group, and the brachial artery diameter was also 0.68 mm more than in the LI-group, both differences were statistically significant ($P < 0.05$). There were significant increases ($P < 0.05$) in the AVF blood flow in the AxBP-group more than the LI-group with mean differences of 29.6, 69.8, and 27.2 ml/min at 4 h, 1 week, and 3 months, respectively. The overall mean of AVF blood flow was 42.21 ml/min more in the AxBP group than the LI-group a difference which is statistically significant ($P < 0.001$). The primary failure rate was 17% in the AxBP group versus 30% in the LI-group; however, this difference is not significant statistically ($P = 0.110$).

Conclusion: The US-guided axillary block increases AVF blood flow significantly more than local infiltration and nonsignificantly decreases the primary failure rate of the AVF after 3 months.

Key words: Arteriovenous fistula, axillary block, local infiltration, ultrasound-guided

Introduction

Patients with chronic renal failure depend on dialysis to maintain life. Creation of an arteriovenous fistula (AVF) is the first choice for gaining access for hemodialysis. Unfortunately, approximately one-third of AVF fails at an early stage.[1] This failure rate is influenced by both the preoperative arterial and venous diameters and postoperative flow through the AVF.[2,3] Some anesthetic techniques can directly influence venous diameter as well as intra- and post-operative blood flow.[2] Maintenance of adequate blood flow through the fistula

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postoperatively can help prevent thrombosis and fistula failure and is important in fistula maturation.[4] Furthermore, arterial and venous spasm reduces flow and is more common with local infiltration than regional anesthesia techniques.[5]

The use of brachial plexus block (BPB) for anesthesia in this procedure appears to improve blood flow through the fistula by causing vasodilation in large arteries by regional sympathetic blockade while minimally altering blood pressure and heart rate.[6,7]

Reducing the AVF failure rate is of significant benefit by increasing the number of patients able to commence hemodialysis when planned and reducing the number of "redo" procedures. This has clear financial benefits and also reduces the inconvenience to patients and the risks of further AVF surgery.[3]

Axillary BPB offers several advantages over the other approaches to the brachial plexus. The technique is relatively simple to perform, and may be associated with a relatively lower risk of complications as compared with interscalene or supraclavicular BPB.[8]

The purpose of this study is to investigate the hypothesis that long-term AVF patency is improved by ultrasound (US) axillary BPB compared to local anesthetic infiltration.

Methods

This study was conducted after approval of ethical committee of Ain Shams University. Written informed consent was obtained from all patients before surgery. The study included hundred and forty patients, aged 21–60 years, who have chronic renal failure and will undergo regular hemodialysis, and had been scheduled for primary AVF access surgery before hemodialysis. All participants need forearm (radio-cephalic AVF) or arm access in the form of brachiocephalic, brachiobasilic, or synthetic graft AVF their physical status, as rated by the American Society of Anesthesiologists criteria, ranged from II to III. Exclusion criteria were: Revision of previously blocked AVF and failed surgical procedure. Patients with contraindicated axillary block as local infection, clinically significant coagulopathy, axillary fibrosis, infection, previous surgery, and tumor. These patients will be excluded from Group 1 and added to Group 2. Also, patients with previously failed access in the same site of the intended procedure, or those with proximal arterial disease as subclavian or axillary stenosis or occlusion detected clinically by absent or weak distal pulse. Patients with known venous hypertension presented by history of permicath insertion or repeated subclavian catheter insertion more than three times at same time were also excluded from the study. A detailed history regarding physical health, coexisting medical problems, current medications, allergies, previous anesthetic, and surgical experience were noted before surgery.

The upper limb, shoulder, and neck were examined to detect any sign of previous trauma, muscle atrophy, or chronic ischemia. Also, all patients will undergo clinical evaluation for normal and equal bilateral radial pulse, neck examination for previous neck catheter insertion, axillary examination to exclude local contraindications for axillary block. In addition, a detailed laboratory work was done for each patient, including total cholesterol/high-density lipoprotein ratio, and the results were recorded.

In the operating room, baseline monitoring was established (electrocardiogram, pulse oximetry, and noninvasive blood pressure monitoring). An intravenous catheter was placed in the contralateral forearm. Patients were randomized into two groups by computer-generated randomization. Patients who required sedation received 1–3 mg of intravenous midazolam.

Patients enrolled in the study were randomly assigned to one of two groups;

Group 1 (AxBP-G) received US-Guided axillary BPB, using a single injection of 20–25 mL of 0.25% bupivacaine to encircle the neural bundles. Group 2 (LI-G), the local infiltration group, the surgical site was infiltrated by the surgeon with 1% lidocaine with papaverine around the artery during the procedure.

Axillary brachial plexus block technique

For performing the US-Guided axillary block, a US machine Mindray M5 (Shenzhen Mindray Bio-Medical Electronics Co., LTD. Shenzhen, China.) with a broadband linear array transducer (5–10 MHz) is used, with an imaging depth of 4 cm. The patient in the supine position, with the arm, abducted and elbow flexed, and after the skin is disinfected and a sterile gel is applied, the transducer is positioned just distal to the insertion of the pectoralis major on the humerus in the short axis orientation to identify the axillary artery. Once the artery is identified, an attempt is made to identify the median, ulnar, and radial nerves, if not clearly visualized; a perivascular injection around the axillary artery is used. The musculocutaneous nerve is identified as a bright echogenic structure between the biceps and the coracobrachialis muscles; sometimes a slight proximal-distal movement of the transducer is often required to bring the musculocutaneous nerve into view. A 50-mm short bevel 22-gauge insulated stimulating needle (PAJUNK® GmbH Medizintechnologie, Deutschland) is used. The needle is inserted in-plane from the cephalad aspect and directed toward the posterior aspect of the axillary artery. Local anesthetic deposited posterior to the artery first, once 5–10 mL is administered, the needle is withdrawn almost to the level of the skin, redirected toward the median and ulnar nerves, and a further 10–15 mL is injected in these areas to complete the circle around the artery. Finally, the needle is once again withdrawn to the biceps and redirected toward the musculocutaneous nerve. Once adjacent to the nerve, 5–7 mL of local anesthetic is deposited.

The adequacy of sensory block was assessed by ice cold test at the surgical site. If the block was not adequate after 20 min, the fistula was created using local anesthetic infiltration and the case was excluded from the study.

A standardized surgical technique was used for the creation of all AVF. Primary success is indicated by the presence of propagating thrill along the vein or graft after anastomosis immediately after surgery.

The primary end point of this study was to find if the axillary block technique decreases the proportion of primary AVF failure compared to the local anesthetic technique. Furthermore, the Doppler readings of the brachial and radial arteries are recorded before and after anesthesia; we also recorded the AVF blood flow in the two groups at different time intervals up to the 3rd month after surgery.

Doppler examination technique

The same U/S machine mentioned before was used. The patient is in supine position with nonflexed limb, is subjected to full arterial and venous Doppler study to report anatomical variation if present, flow dynamics and any abnormalities. Arterial examination starts with subclavian artery, axillary, brachial, and ending up with ulnar and radial arteries. Wall morphology is recorded for any stenotic areas or calcifications, high bifurcation of brachial artery is recorded if present (5–10% of population), Doppler velocities are recorded in each artery namely the peak systolic and the end diastolic velocity, in longitudinal orientation with adjustment of the sample volume to be third the diameter of the artery and placed in the midstream, steer button is used for better detection of blood flow and the angel corrected to below 60° for reliable measures. Brachial artery diameter is measured at the elbow, and the radial artery diameter also is recorded with the probe in transverse orientation.

Venous examination

Deep system is examined for any thrombosis, occlusion, and reflux. The proximal axillary vein, subclavian and internal jugular vein will be evaluated by color flow imaging. A duplex angle-corrected spectral Doppler signal of the subclavian vein will be obtained to evaluate the subclavian vein for indirect assessment of proximal DVT. The rest of the deep system will be examined by compressibility test using transverse orientation of the probe. Cephalic and basilic veins are superficial veins, examined for patency by compression and diameter measurement using transverse orientation of the probe the vein is subjected to compressibility test and diameter measurement starting from above till the diameter is <3 mm.

Statistical analysis

Data were analyzed using Statistical Package for Social Science version 21.0. Chicago, Illinois, USA. Quantitative data were expressed as mean ± standard deviation. Qualitative data were expressed as frequency and percentage. Independent-samples t-test of significance was used when comparing between means in the two groups. Two-way analysis of variance (ANOVA) was used for comparisons between both groups at different levels of time and anesthesia type. *Post hoc* analysis with Bonferroni adjustment was used for multiple comparisons. Chi-square test was used to compare proportions between two qualitative parameters. $P < 0.05$ was considered significant and $P < 0.01$ was considered highly significant. Sample size was calculated to find a significant reduction of 50% in the primary failure rate in the AxBP group. Assuming a failure rate in the AxBP that ranges between 15–20% and 30–35% in the LI-G, a sample size of seventy patients in each group is needed to detect such difference if exists at 0.05 alpha error and 0.8 power of the test.

Results

Two patients were excluded from the AxBP-group due to inadequate axillary block and were replaced by another two patients.

Data were normally distributed for both groups as assessed by Shapiro-Wilk's test ($P > 0.05$). Descriptive analysis revealed no significant difference between both groups as shown in Table 1.

An independent-samples t-test was run to check for mean differences between both groups in brachial artery diameter and radial artery blood flow before and after anesthesia. No significant differences were detected between the two groups before anesthesia ($P > 0.05$); however, after the anesthesia was given the mean radial artery blood flow in the AxBP-group was 3.52 ml/min more than the LI-group, and the brachial artery diameter was also 0.68 mm more than the LI-group, both differences were statistically significant ($P < 0.05$) as shown in Table 2.

A two-way repeated measures ANOVA was used to determine the effect of the anesthesia type over time on the fistula blood flow, and to detect if a significant interaction term exists between type of anesthesia and time. Sphericity for the interaction term was violated as indicated by Mauchly's test of sphericity ($P < 0.05$), Therefore, a Greenhouse-Geisser correction[9] was applied ($\varepsilon = 0.575$). There was a statistically significant interaction term between type of anesthesia and time, F (1.15, 27.6) $= 14.935$, $P < 0.001$and by inspecting the plot in Figure 1. Therefore, simple main effects were tested for both groups and time variables.

Testing the effect of anesthesia type given over time revealed significant increases in the AVF blood flow in the AxBP-group more than the LI-group ($P < 0.05$) with mean differences of 29.6, 69.8, and 27.2 ml/min at 4 h, 1 week, and 3 months, respectively. All the mean differences and their confidence intervals are shown in Table 3.

In addition, the increases between each time points were significant in each group separately. The increases in fistula flow between different time points and their confidence intervals are shown in the pairwise comparison [Table 4].

The overall mean of AVF blood flow was 42.21 ml/min (95% confidence interval, 35.37–49.06) more in the AxBP group than the LI-group a difference which is statistically significant ($P < 0.001$) [Figure 2].

The primary failure rate was 17.1%(12/70) in the AxBP group versus 30% (21/70) in the LI-group [Figure 3]. However, this difference is not statistically significant (P=0.110).

Table 1: Descriptive analysis of the patients

	LI-Group	AxBP-Group	*P* value
Age (years)	42.42±5.41	39.52±5.46	0.08
Number of males	36 (51.4)	39 (55.7)	0.78
BMI	26.84±1.42	27.58±1.83	0.11
Cholesterol/HDL	3.87±0.35	3.74±0.36	0.19
Radial artery internal diameter (mm)	2.96±0.29	2.92±0.24	0.61
Cephalic vein internal diameter (mm)	3.45±0.36	3.54±0.32	0.33
Primary failure rate	21 (30%)	12 (17.1%)	0.110*

Data are presented as mean±SD or count (%) All *P* values are measured by independent *t*-test except primary failure rate *Measured by Chi-square test

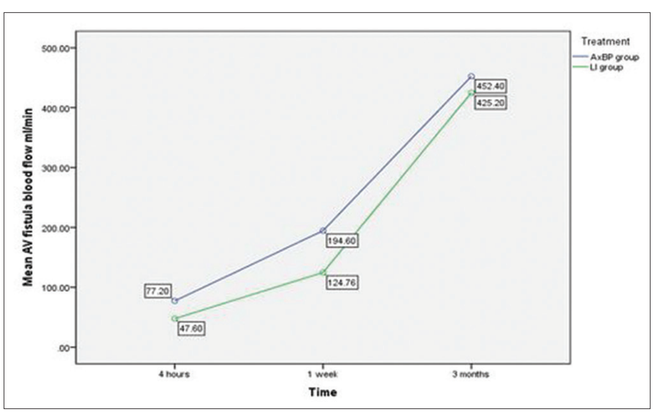

Figure 1: Mean arteriovenous fistula blood flow at the three time points in both groups

Discussion

US-Guided Regional blocks are safe, effective, and a preferred technique for providing anesthesia for upper extremity vascular surgery. Vascular surgical procedures are particularly prone to vessel spasm, possibly because of increased sympathetic tone and local handling of vessels, which can impair blood flow and potentially lead to early thrombosis of the fistula.[10] The use of regional anesthesia, compared with other anesthetic techniques such as general anesthesia and infiltration anesthesia, has been shown to result in higher patency rates.[3]

Results of the present study indicate that ultrasonography (USG) axillary BPB provides higher blood flow in the radial artery and AVF in both the early and late postoperative periods as compared with AVF created under local infiltration anesthesia this was probably due to vasodilatation, decreased vascular resistance, and greater blood velocity in the axillary plexus group. These results were supported by Malinzak and Gan, who suggested that use of regional blocks may improve the success of vascular access procedures by producing significant vasodilatation, greater fistula blood flow, sympatholytic effects , and decreased maturation time while minimally altering blood pressure and heart rate.[3]

Similar to the result of our study, Mouquet *et al*. also reported that after BPB, brachial artery diameter and blood flow, as well as AVF blood flow, increased compared with controls.[4] also

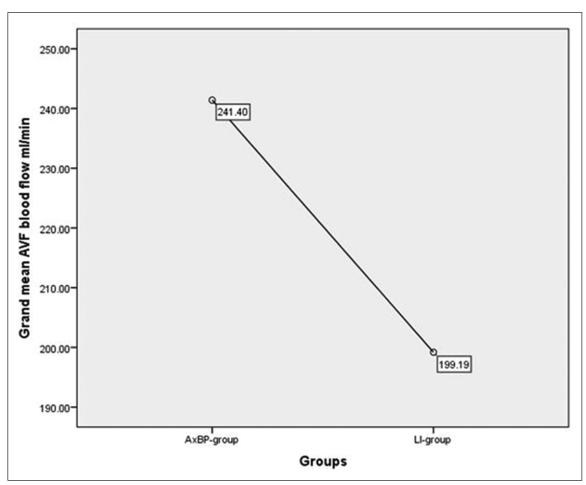

Figure 2: Overall mean arteriovenous fistula blood flow in both groups

Table 2: Mean differences of Doppler findings before and after anesthesia

	AxBP-gr	LI-gr	*P* value	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Brachial Art diameter before anesthesia (mm)	4.5±0.3	4.6±0.3	0.404	−0.07	−0.24	0.10
Brachial Art diameter after anesthesia (mm)	5.4±0.4	4.7±0.3	0.001	0.68	0.47	0.88
Radial artery flow before anesthesia (ml/min)	40.9±1.03	41.4±1.86	0.215	−0.53	−1.39	0.32
Radial artery flow after anesthesia (ml/min)	45.3±3.01	41.8±1.55	<0.001	3.52	2.15	4.88

Data are presented as mean±SD *P* values are measured by independent *t*-test

Table 3: Pairwise comparisons between both groups at the 3 time points examined regarding AVF blood flow

Time point	Mean Diff (1-2)	Std. Error	*P* value	95% Confidence Interval for Difference	
				Lower Bound	Upper Bound
At 4hrs	29.600	1.681	<0.001	26.130	33.070
At 1wk	69.840	3.026	<0.001	63.594	76.086
At3 months	27.200	9.891	0.011	6.785	47.615

Table 4: Pairwise comparisons between different time points in each group separately regarding AVF blood flow

Time 1-2	Mean Diff (1-2)	Std. Error	*P* value	95% Confidence Interval for Difference	
				Lower Bound	Upper Bound
AxBP-group					
3m-1wk	257.800	9.354	<0.001	238.493	277.107
1wk-4hrs	117.400	2.434	<0.001	112.375	122.425
3m-4hrs	375.200	9.117	<0.001	356.383	394.017
LI-group					
3m-1wk	300.440	3.174	<0.001	293.888	306.992
1wk-4hrs	77.160	2.366	<0.001	72.276	82.044
3m-4hrs	377.600	2.874	<0.001	371.668	383.532

Ebert *et al*.[7] reported that the average arterial and venous blood flows were increased 1.9 and 8.6 times, respectively, after BPB. Lehtipalo *et al*.[11] reported that interscalene BPB reduces regional sympathetic nervous activity, resulting in increases in skin blood flow, skin temperature, and attenuated vasoconstrictor responses.

In this study, preoperative vessel diameter of more than 2.5 mm was considered, and there was significant increase in vessel diameter in the AxBP-group compared to LI-group. Brimble and colleagues reported that a minimum preoperative venous diameter of 2.5 mm was required for fistula maturation.[12]

Silva and colleagues also suggested a minimum of 2.5 mm preoperative cephalic vein diameter and reported good AVF outcomes (8% early failure, 83% functional primary patency at 1 year).[13]

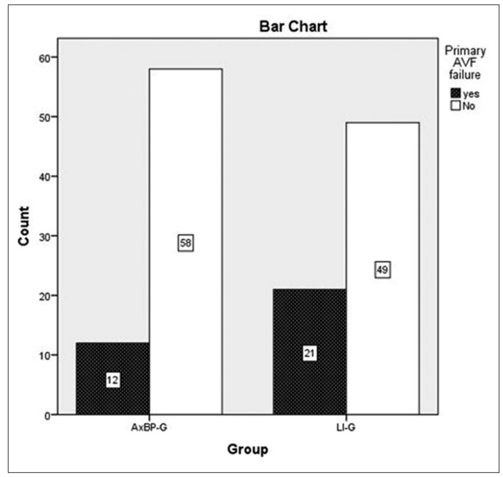

Figure 3: The primary failure rate in both groups after 3 months

In this study, the AVF blood flow changes differently over time depending on the type of anesthesia given as indicated by the significant 2-way group time interaction effect. The overall mean of AVF blood flow was 42.21 ml/min more in the AxBP group than the LI-group a difference which is statistically significant Malovrh reported a similar mean preoperative flow rate of 54.5 ml/min in vessels with a successful outcome and a mean flow rate of 24.1 ml/min in those that failed.[14]

The primary failure rate was 17% in the AxBP group versus 30% in the LI-group, which was not significant statistically and there are no complications related to the USG axillary block technique, which supports the notion that USG injection is a simple and safe technique in performing BPB.

Conclusion

This study suggests that USG axillary BPB was much better for AVF flow characteristics including diameter, blood flow, and patency as compared with local infiltration anesthesia.

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Conflicts of interest

There are no conflicts of interest.

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